MASTER OF SCIENCE
IN
PHYSICS

FUSION NEUTRON DAMAGE TO A CHARGE COUPLED DEVICE CAMERA

Christopher Dean Amaden-Lieutenant, United States Navy
B. S., University of South Florida, 1990
Master of Science in Physics-September 1997
Advisors: William B. Maier II, Department of Physics
Xavier K. Maruyama, Department of Physics

A charge coupled device (CCD) camera's performance has been degraded by damage produced by 14 MeV neutrons (n) from the Rotating Target Neutron Source. High-energy neutrons produce atomic dislocation in doped silicon electronics. This thesis explores changes in Dark Current (J), Charge Transfer Inefficiency (CTI), and Contrast Transfer Function (CTF) as measures of neutron damage.

The camera was irradiated to a fluence, ϕ, of 6.60×10^{12} n/cm^2. The camera temperature was lowered from room temperature to 267 K at a fluence of 4.7×10^{11} n/cm^2 to preclude saturation of the camera picture. With temperature compensations, J increased linearly with ϕ. Four data points for J, CTF (ideal of 1.0) and CTI (ideal of 0) are:

Fluence (n/cm$^{2)}$	0	4.7×10^{11}	4.7×10^{11}	6.60×10^{12}
Temp (K)	292.1	296.1	276	266.8
J (nAcm^2	0.37	11	0.93	9.8
CTF	0.89	0.37	0.82	0.48
CTI	1.3×10^{-4}	1.2×10^{-3}	2.4×10^{-4}	1.6×10^{-3}

Neutron irradiation significantly degraded CCD camera performance; however, operating the camera at lower temperatures significantly reduces the effects. Damage thresholds for fluences greater than 6.60×10^{12} n/cm^2 and for all temperatures can be extrapolated from this work.

NUMERICAL SIMULATION OF BLOCH OSCILLATIONS IN PERIODIC STRUCTURES

Walter A. Coppeans III-Lieutenant, United States Navy
B.S., United States Naval Academy, 1990
Master of Science in Physics-December 1996
Advisors: James H. Luscombe, Department of Physics
Robert L. Armstead, Department of Physics

Felix Bloch's 1928 article made a prediction concerning the dynamical behavior of electrons in a solid, subject to a uniform, static electric field. This aspect of his work, as later clarified by Zener, showed that electrons accelerated by an electric field in a periodic potential, under the right conditions, would oscillate. A theoretical debate as to the existence of this phenomenon has been ongoing since Bloch's proposal. One of the most controversial consequences of this prediction is that an electron undergoing Bloch oscillations would radiate. The controversy on the theoretical analysis was due to the great difficulty in systematically and reliably treating interband transitions by analytical methods based on the time-dependent Schrodinger equation is numerically solved for independent electrons. In this thesis, the time-dependent Schrodinger equation is numerically solved to show that electrons accelerated by an electric field in periodic structures do undergo Bloch

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oscillations and other dynamic behavior. By accurately modeling this phenomenon a better understanding of it will be gained in hopes of using it in future applications as a stable source of Terahertz (THz) radiation.

DESIGN, CONSTRUCTION AND INSTRUMENTATION OF A THERMOACOUSTIC PRIME MOVER WITHOUT A STACK
Paul A. Fleischman-Lieutenant Commander, United States Navy
B.A., University of New Mexico, 1986
Master of Science in Physics-September 1997
Advisor: Robert M. Keolian, Department of Physics
Second Reader: Thomas J. Hofler, Department of Physics

This thesis is written to document the design, construction and instrumentation of a thermoacoustic prime mover without a stack. A thermoacoustic prime mover uses a temperature differential maintained between two heat exchangers to produce sound, i.e., work in a resonator. The no stack design may offer improved efficiencies over current designs which use a stack by eliminating the thermal and viscous losses associated with the stack. A detailed description of the construction of the experimental components and the instrumentation is provided.

NUMERICAL SIMULATIONS OF SHOCKLESS NONLINEAR ACOUSTICS NOISE IN ONE DIMENSION
Hyeon Joo Jang-Captain, Republic of Korea Army
B.S., Korea Military Academy, 1990
Master of Science in Physics-December 1996
Advisor: Andrés Larraza, Department of Physics
Bruce C. Denardo, University of Mississippi

The attenuation of a monochromatic signal in the presence of discrete noise in one dimension is investigated numerically. The predicted Gaussian attenuation is verified by the numerical program, which is based on Riemann's implicit solution of the exact equation for the unidirectional propagation of shockless sound. Two new results are also presented. In the first, the transition from Gaussian to Bessel dependence as a function of resolution in the detection of a signal is observed. This results shows that the fundamental property of time reversibility can only be established if the overall system of the waves and the observer is considered. In the second result, the evolution of the amplitude of a signal injected downstream from the noise is investigated. The Gaussian attenuation is also observed in this case. This result explicitly shows that the attenuation length depends on the distance the signal has traveled, thus displaying memory and breakdown of translational invariance.

FREE ELECTRON LASER WEAPONS AND ELECTRON BEAM TRANSPORT
Rick A. Restivo-Lieutenant, U.S. Navy
B.S., Texas A&M University, 1991
Master of Science in Physics-June 1997
Advisors: William B. Colson, Department of Physics
Robert L. Armstead, Department of Physics

The Navy is exploring the possibility of using a MW class free electron laser (FEL) as a ship self-defense weapon against anti-ship missiles. The Navy has helped fund the construction of a KW average power FEL and has held workshops to discuss weapons class FELs.

A design workshop resulted in two possible MW FELs which are examined. One of these designs, the MW regenerative amplifier FEL, is looked at further to determine the feasibility of its design parameters. The second design, the MW oscillator FEL, presents a challenge in understanding the electron beam transport phenomena known as coherent synchrotron radiation (CSR). A workshop concluded that CSR is potentially disruptive in the electron beam recovery in the oscilla-

tor design. Possible CSR experiments are analyzed to help the Navy's Directed Energy office determine which, if any, CSR experiment will be useful.

SOLAR HEATING EFFECTS ON BALLOON-BORNE MICROTHERMAL PROBES FOR THE AIRBORNE LASER PROGRAM

Daniel J. Richardson-Lieutenant Commander, United States Navy
B.S., United States Naval Academy, 1985
Master of Science in Physics-June 1997
Advisors: Donald Walters, Department of Physics
D. Scott Davis, Department of Physics

Atmospheric optical turbulence induces phase fluctuations in a propagating electromagnetic wave. The resulting degradation in coherence limits the capability of any laser, target acquisition, or surveillance system. Past data collection methods for the parameterization of atmospheric turbulence profiles, in support of critical Theater Ballistic Missile Defense (TBM) systems, from ground level to 30 km, have depended on meteorological balloon-thermosonde systems, probes carried on the U.S. Air Force Argus aircraft, as well as radar and optical measurements. The balloon and aircraft systems measure temperature fluctuations and compute the temperature structure function, C_T^2 and the related index of refraction structure parameter, C_n^2. It has recently become critical to explain why turbulence profiles from daytime thermosonde data consistently show a two order of magnitude increase over that taken during the night, primarily between 12-20 km.

This thesis analyzed the TSI 3.8 μm platinum coated tungsten thermosonde probe used by the USAF Research Laboratory (AFRL) to quantify the magnitude of the solar heating and to investigate other heat transfer mechanisms in the probe. A model of the thin wire probe was developed to identify each of the contributions to the temperature error and its significance. Experimental measurements where collected to verify most aspects of the final model.

We found that the sun induces a temperature rise in the TSI 3.8 μm fine wire probe, during the day, that can vary from near zero to 0.175 K. It is strongly dependent on probe orientation with respect to the sun and on variations in the air flow over the probe. This then causes an apparent increase by two orders of magnitude in the daytime measurements of the optical turbulence parameters C_T^2 and C_n^2.

EVOLUTION OF THE TEMPERATURE PROFILE IN A SIMPLE THERMOACOUSTIC STACK

Arthur R. Salindong-Lieutenant Commander, United States Navy
B.S., United States Naval Academy, 1982
Master of Science in Physics-December 1996
Master of Science in Engineering Acoustics-December 1996
and
David D. Hebert-Lieutenant, United States Navy
B.S., United States Naval Academy, 1990
Master of Science in Physics-December 1996
Advisors: Anthony A. Atchley, Department of Physics
Robert M. Keolian, Department of Physics

The purpose of this thesis is to provide data on the evolution of the temperature profile in a simple thermoacoustic stack. These measurements are made to support the development of nonlinear time-dependent models of thermoacoustics. An acoustic resonator and driver is used with a five-plate stainless steel stack. The center plate of the stack is instrumented with nine thermocouples, one in the midpoint and four near each end of the plate. The edge thermocouples are located within an acoustic displacement amplitude of one another at high amplitude drive conditions.

Temperature evolution data is recorded for both argon and helium gases at several mean pressures and several drive ratios with the stack located between a pressure node and antinode. This data showed a deviation from linear theory at drive ratios above 1.5%. A crossover of gradient magnitudes is evident during gradient formation with edge thermocouple pairs initially forming larger gradients but dropping in magnitude to less than those of the inner thermocouple pairs after 25-50

seconds. As the gradients approached steady state conditions, they split into two groups of gradient pairs that appeared independent of displacement amplitude. Measurements are also made with the stack positioned in the vicinity of a pressure node and a pressure antinode. This data will be used for future study.

BATHYMETRY FROM HYPERSPECTRAL IMAGRY

L. Douglas Stuffle-Lieutenant, United States Navy
B. S., University of Arizona, 1990
Master of Science in Physics-December 1996
Advisors: R.C. Olsen, Department of Physics
Newell Garfield, Department of Oceanography

This work used hyperspectral imagery to derive shallow water depth estimates. A technique to classify substrates and estimate reflectance values for the substrate types is the major contributions of this work. This was accomplished by masking different bottom types based on spectra, effects that were not included in previous methods. HYDICE data was taken over Lake Tahoe on June 22, 1995. The high altitude of the lake provided a low aerosol content within the atmosphere. This allowed for relatively straightforward atmospheric corrections. This was substantially easier than in an oceanic environment. The atmospheric radiative transfer code MODTRAN3.0 was used to model the atmospheric conditions at the time of the experiment. The radiative transfer code HYDROLIGHT3.5 was used to model the attenuation coefficients of the relatively clear water of the lake. Minimal river input and low chlorophyll concentrations made it simpler to determine these values. Making use of the full spectral content of data within the optical range, multiple substrates were differentiated and masked off. This allowed for an estimation on wet substrate reflectance and a straightforward calculation of bottom depth.